Repeated measures on the recursion data

```
> rm(list=ls()); options(scipen=999) # To avoid scientific notation
> rec1 = read.table("recursion-horizontal.data.txt",header=T)
> head(rec1)
  Participant AgeinMonths Group AgeGroups KABC_Concept KABC_Face KABC_Tri
1           1        48.5 Child      4yos            7        13       13
2           2        63.9 Child      5yos           19        12       16
3           4        64.2 Child      5yos           11         8       18
4           5        71.6 Child      5yos           14        11       24
5           6        53.1 Child      4yos           14         5       13
6           7        55.5 Child      4yos           13        13       11
  KABC_Pattern KABC_Hand CELF_SS CELF_WS CELF_EV CELF_ConDir CELF_Sent
1           NA         4      16      13      22           8        21
2            7         7      19      22      29          16        34
3            4         5      16      15      31          14        26
4            9         5      21      19      30          12        27
5           NA         5      19      21      36          19        34
6           NA         5      18      17      34          15        19
  CELF_Basic PPVT KBIT RecursionStrictTarget RecursionALLtargets
1         16   92   NA            0.10344828          0.10344828
2         NA   96   NA            0.35483871          0.35483871
3         NA  108   NA            0.12903226          0.35483871
4         NA  102   NA            0.06451613          0.16129032
5         16  111   NA            0.29032258          0.45161290
6         17   99   NA            0.06451613          0.06451613
   A.Strict  B.Strict  C.strict E.Strict A.alltargets B.alltargets
1 0.1666667 0.3333333 0.0000000        0    0.1666667    0.3333333
2 0.5714286 0.5000000 0.1666667        0    0.5714286    0.5000000
3 0.2857143 0.0000000 0.1666667        0    0.2857143    0.5000000
4 0.2857143 0.0000000 0.0000000        0    0.4285714    0.0000000
5 0.4285714 0.1666667 0.5000000        0    0.4285714    0.6666667
6 0.2857143 0.0000000 0.0000000        0    0.2857143    0.0000000
  C.alltargets E.alltargets
1    0.0000000    0.0000000
2    0.1666667    0.0000000
3    0.3333333    0.1666667
4    0.1666667    0.0000000
5    0.5000000    0.1666667
6    0.0000000    0.0000000
>
> # Let's try adult vs child (between) by Condition ABCE, with the dependent
variable proportion of strictly recursive responses.
>
> # Extract the variables we need.
> Group = rec1$Group
> Strict = rec1[,20:23]; head(Strict)
   A.Strict  B.Strict  C.strict E.Strict
1 0.1666667 0.3333333 0.0000000        0
2 0.5714286 0.5000000 0.1666667        0
3 0.2857143 0.0000000 0.1666667        0
4 0.2857143 0.0000000 0.0000000        0
5 0.4285714 0.1666667 0.5000000        0
6 0.2857143 0.0000000 0.0000000        0
> dim(Strict)
[1] 84  4
```

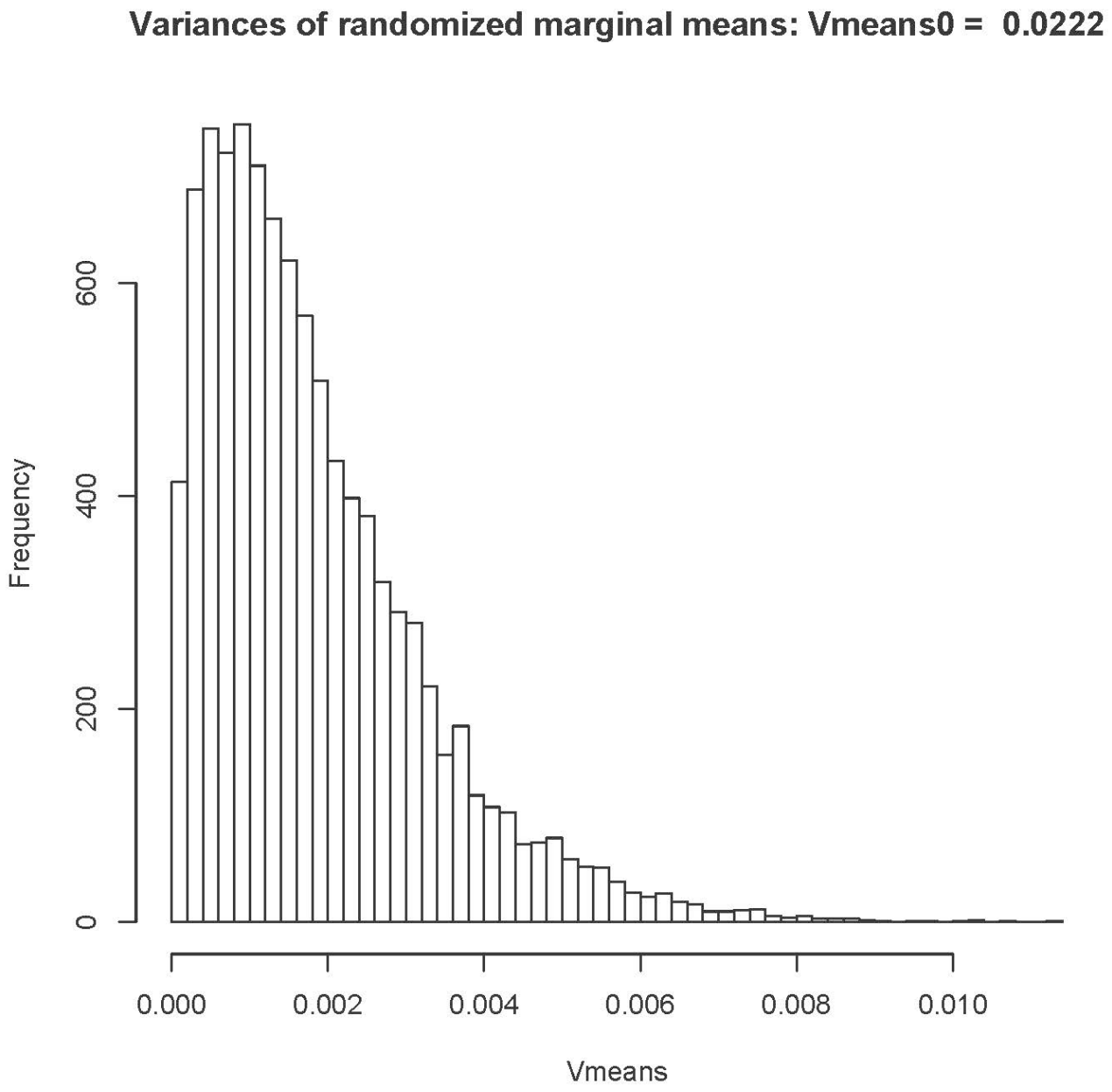
```
>
> # Look at means
> aggregate(Strict,by=list(Group),FUN=mean)
  Group.1  A.Strict  B.Strict  C.strict   E.Strict
1   Adult 0.6043956 0.3717949 0.2179487 0.13076923
2   Child 0.2287726 0.1150235 0.0657277 0.01643192
> Means = as.matrix(aggregate(Strict,by=list(Group),FUN=mean)[,2:5]); Means
      A.Strict  B.Strict  C.strict   E.Strict
[1,] 0.6043956 0.3717949 0.2179487 0.13076923
[2,] 0.2287726 0.1150235 0.0657277 0.01643192
> rownames(Means) = c("Adult","Child")
> addmargins(Means,FUN=mean, quiet=T)

       A.Strict  B.Strict  C.strict   E.Strict      mean
Adult 0.6043956 0.3717949 0.2179487 0.13076923 0.3312271
Child 0.2287726 0.1150235 0.0657277 0.01643192 0.1064889
mean  0.4165841 0.2434092 0.1418382 0.07360058 0.2188580
```

Strategy: We are not interested in testing Adult vs. Child averages, though we could. Let the responses from each participant stay together. They are what they are. But perhaps any apparent main effect for Condition and any apparent Group by Condition interaction came from the random ordering of presentation of the conditions.

Measure difference among marginal means for condition by the variance of the marginal means. Measure the interaction ("it depends") by the variance of the adult-child differences.

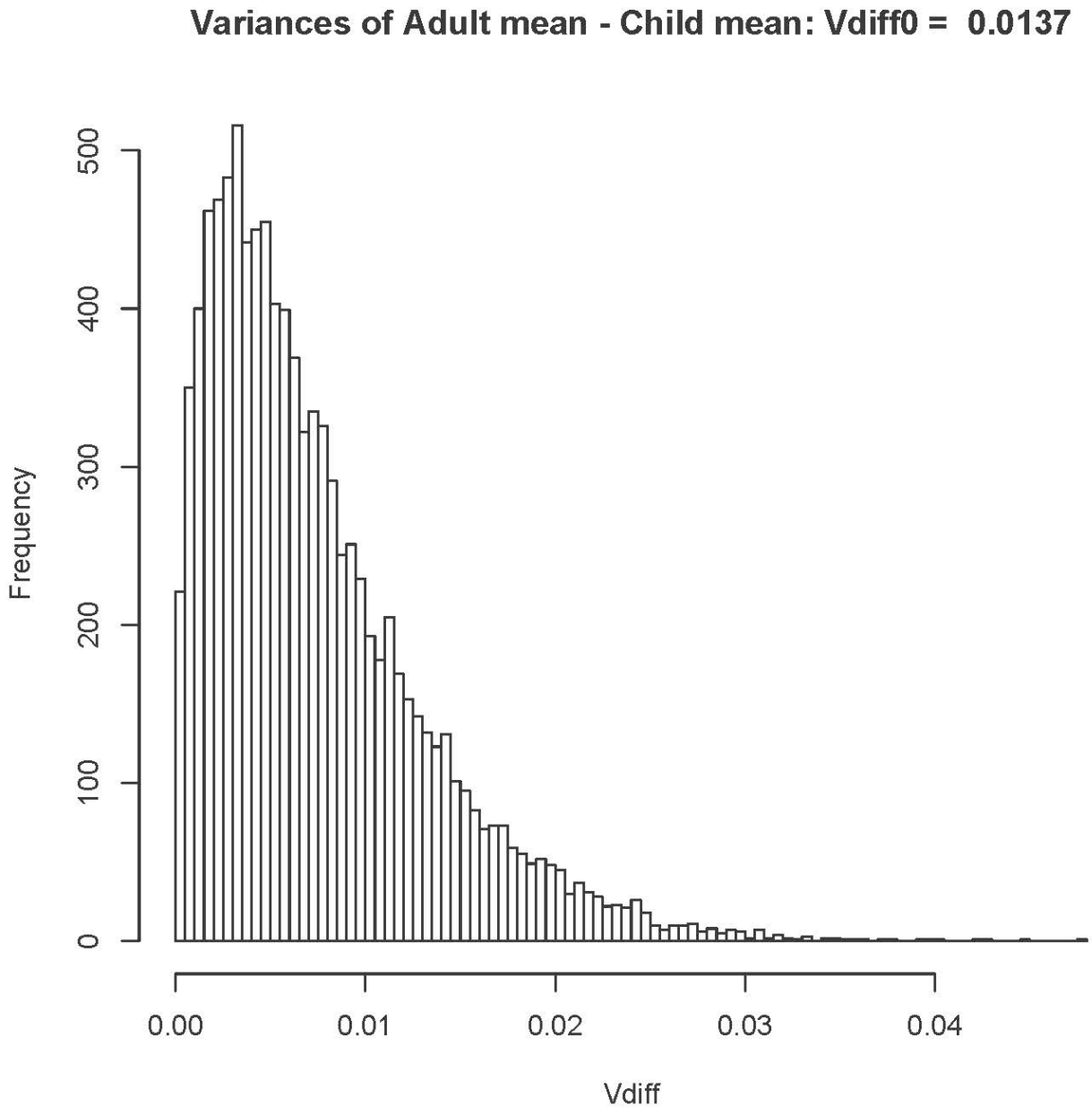
```
> # Condition (marginal) means and adult-child differences
> Conmeans = apply(Means,2,mean); Conmeans
  A.Strict   B.Strict   C.strict   E.Strict
0.41658412 0.24340917 0.14183821 0.07360058
> D = Means[1,]-Means[2,]; D # Row 1 minus row 2
 A.Strict  B.Strict  C.strict  E.Strict
0.3756230 0.2567714 0.1522210 0.1143373
>
> # Test statistics
> Vmeans0 = var(Conmeans); Vmeans0 # Variance of the marginal means
[1] 0.02224338
> Vdiff0 = var(D); Vdiff0 # Variance of the differences
[1] 0.01374648

> # Randomize
> set.seed(9999); nsim = 10000
> Vmeans = Vdiff = numeric(nsim) # To hold simulated test statistics
> n = length(Group); n
[1] 84
>
> for(j in 1:nsim)
+     {
+     strict = Strict
+     for(i in 1:n) strict[i,] = sample(strict[i,]) # Shuffle row i
+     # Make a table of means for the shuffled data
+     means = as.matrix(aggregate(strict,by=list(Group),FUN=mean)[,2:5])
+     # Compute test statistics
+     conmeans = apply(means,2,mean)
+     d = means[1,]-means[2,]
+     # Store the test statistics
+     Vmeans[j] = var(conmeans)
+     Vdiff[j]  = var(d)
+     } # Next simulation j
>
```

```
> # That took a few minutes.
> title1 = paste('Variances of randomized marginal means: Vmeans0 = ',
+                round(Vmeans0,4))
> hist(Vmeans,breaks='fd', main = title1)
```




```
> # p-value
> p1 = length(Vmeans[Vmeans>=Vmeans0])/nsim; p1 # Main effect for condition
[1] 0
> c(Vmeans0,max(Vmeans))
[1] 0.02224338 0.01121872
```

```
> title2 = paste('Variances of Adult mean - Child mean: Vdiff0 = ',round(Vdiff0,4))
> hist(Vdiff,breaks='fd', main = title2)
```




```
> # p-value
> p2 = length(Vdiff[Vdiff>=Vdiff0])/nsim; p2 # Group by Condition interaction
[1] 0.1344

> # Comparable mixed model results (For all targets)
> # p-value for Condition was approximately zero
> # p-value for Group by Condition was 0.746.
```